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Plan pursuit in the context of daily fruit and vegetable consumption: The importance of cue detection and the execution of the planned behaviour for overall behaviour change

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Objectives. In action planning interventions, individuals specify and link cues with behavioural responses to implement behaviour change. To date, not much is known about how and how much the detection of the planned cue (entering and identifying the planned situation) and the execution of the planned behaviour (behavioural response exactly as planned) contribute to overall behavioural changes (changes in target behaviour) achieved by individuals. Using data from an intervention on daily fruit and vegetable (FV) action planning, this study aimed to test whether individuals' cue detection and execution of the planned behaviour are positively related to overall FV intake.

Design. Secondary data analyses examined diary data of the intervention condition of a randomized controlled trial. Ninety participants (80% female, aged 19–63 years) formed one FV plan and completed a 13-days post-intervention self-report diary assessing daily FV consumption and situational characteristics of each consumed FV serving. Based on these self-reports and participants' FV plan, day-to-day cue detection and the execution of the planned behaviour were coded.

Methods. With two-level models, cue detection and the execution of the planned behaviour were examined as between- and within-person predictors of daily FV intake.

Results. Higher between-person execution of the planned behaviour (+1.68 daily servings), higher-than-usual within-person cue detection (+0.46 daily servings), and higher-than-usual within-person execution of the planned behaviour (+0.29 daily servings) were associated with more overall FV intake.

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Conclusions. Detecting planned cues (within-person) and executing the planned behaviour (between- and within-person) are important for overall FV intake.

Statement of contribution

What is already known on this subject?

- Action planning is linked to behavioural increases across various health behaviours.
- Theoretical frameworks on action planning highlight the importance of cue detection and execution of the planned behaviour.
- Repeated plan enactment is positively related to overall health behaviour outcomes.

What does this study add?

- Cue detection and execution of the planned behaviour occurred frequently in the context of planning one's fruit and vegetable (FV) intake.
- Cue detection (within-person) and the execution of the planned behaviour (between- and within-person) were positively related to daily FV intake.
- Enacting the plan exactly as planned was not superior to either cue detection or executing the planned behaviour.

Background

Insufficient fruit and vegetable (FV) consumption is detrimental for health and associated with health risks for several diseases (e.g., hypertension and cardiovascular disease) as well as all-cause mortality (Aune et al., 2017). Although it is recommended by international guidelines to consume at least five daily servings of FV, the global adherence to these recommendations is comparatively low (Hall, Moore, Harper, & Lynch, 2009; Livingstone, Burton, Brown, & McNaughton, 2020). As proposed by the behaviour change theories (e.g., Health Action Process Approach, HAPA; Schwarzer, 2008), *action planning* is a frequently used and evidence-based intervention strategy aiding the translation of intentions into actions (Gollwitzer, 1999; Hagger & Luszczynska, 2014). By forming plans, individuals determine *how* to fulfil unconditional goal intentions (e.g., 'I want to eat more healthily') by linking situational cues (e.g., *when* and *where*) to goal-directed actions (*what to do*; Sniehotta, 2009). For FV intake, a sample action plan would be: eating an apple (what) at 8 am (when) in the kitchen (where). Linking actions to situational cues and acting when situational conditions arise is the driving mechanism of planning for behaviour change.

To date, most empirical studies focused on unconditional health behaviour outcomes, such as total physical activity (Bélanger-Gravel, Godin, & Amireault, 2013) or healthy eating (Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011). Sniehotta (2009) argued that when examining the effects of action plans (or implementation intentions; Gollwitzer, 1999) a distinction between conditional and unconditional planning effects should be made. Whereas unconditional effects summarize all goal-directed health behaviours (i.e., overall FV intake), planning leads to *conditional effects* when the planned behaviour (e.g., eating an apple) is performed upon cue detection, that is, under the planned conditions (e.g., at 8 am in the kitchen). The present study investigates plan pursuit mechanisms by examining a persons' *cue detection* and *execution of the planned behaviour* after forming an FV action plan. We aim to examine different types of plan pursuit based on individuals' cue detection and their execution of the planned behaviour for overall behaviour change in the context of day-to-day FV intake.

Plan pursuit after forming action plans

Forming action plans has been found to be an effective health behaviour change strategy (Gollwitzer & Sheeran, 2006), in particular for dietary behaviours (Adriaanse et al., 2011). The success of planning interventions is commonly evaluated by their effects on overall health behaviour outcomes, such as overall FV intake (Adriaanse et al., 2011). However, effects on overall health behaviour outcomes could be the result of regular plan enactment (de Vries, Eggers, & Bolman, 2013), which, as a more proximal outcome, refers to the extent to which individuals execute the behaviour in the situation exactly as planned. For instance, planning to additionally eat an apple each day and successfully executing this ‘new’ behaviour (i.e., regular plan enactment) will increase one’s daily FV consumption by one serving (i.e., overall effect). Moreover, earlier research highlighted the need to differentiate between carrying out the planned behaviour in the planned situation (i.e., upon cue detection) versus performing it in a different situation (Orbell, Hodgkins, & Sheeran, 1997; Sniehotta, 2009).

Thus, to further develop the understanding of how action plans from interventions can impact behavioural outcomes, we outline different types of plan pursuit based on individuals’ cue detection and execution of the planned behaviour for overall behaviour change (Figure 1). As illustrated by the sample action plan of eating an apple (what) at 8 am (when) in the kitchen (where), we distinguish between (1) opportunities in which individuals are exposed to and detect their planned cue (versus no cue detection) and (2) the execution of the planned behaviour (versus a different goal-directed behaviour). The combination of these two components results in four different types of plan pursuit. These comprise (1) performing the planned behaviour in the planned situation (i.e., *conditional planning effects;* Sniehotta, 2009; e.g., eating the planned apple at 8 am in the kitchen), (2) executing a different goal-directed behaviour in the planned situation (e.g., eating a banana at 8 am in the kitchen), (3) performing the planned behaviour in a different situation (i.e., a different time and/or location; e.g., eating the planned apple at 1 pm in the cafeteria), and (4) executing a different goal-directed behaviour in a different situation (e.g., eating a banana at 1 pm in the cafeteria).

Each of these types of plan pursuit refers to the consumption of at least one serving of fruit and would contribute to a persons’ overall FV intake for that day. The question remains how cue detection and the execution of the planned behaviour contribute to a persons’ daily overall FV intake. The present study allows for the investigation of different types of plan pursuit on a day-to-day basis as FV intake is an everyday behaviour (Mensink,

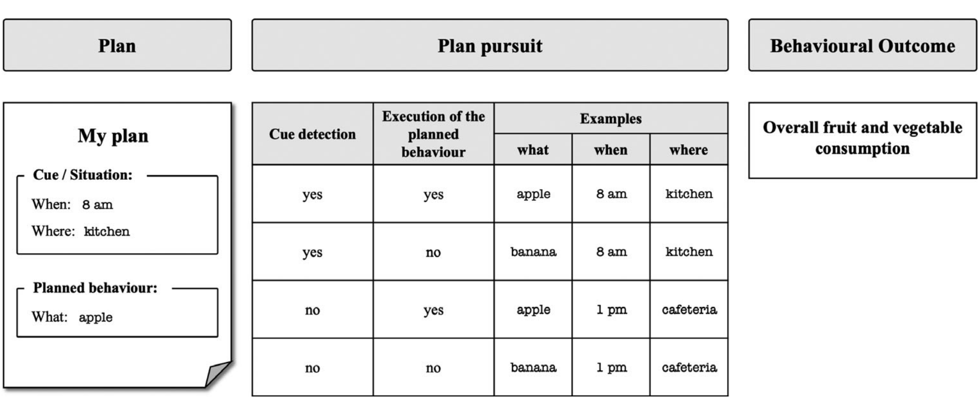

Figure 1. Behavioural response matrix after plan formation including different types of plan pursuit.

Schienkiewitz, & Lange, 2017a, 2017b) and individuals show day-to-day variations in following their plan or deviating from it (Wiedemann, Lippke, & Schwarzer, 2012).

The role of cue detection and the execution of the planned behaviour for health behaviour change

In theoretical approaches on implementation intentions and action plans (Gollwitzer, 1999; Hagger & Luszczynska, 2014) it is assumed that identifying a cue and planning to act upon its detection will yield heightened mental accessibility of the cue, making its detection in subsequent situations more likely. Moreover, it is assumed, that the detection of the planned cue is a prerequisite for acting upon it. With repeated cue detection and execution of the planned behaviour, the planned behavioural response is shifted from being consciously controlled by the individual to an automatic elicitation upon encountering the cue (Gollwitzer, 1999). A number of studies have found evidence for the positive relationship between plan enactment and health behaviour change, for instance in the domain of physical activity (Fleig et al., 2017), smoking cessation (de Vries et al., 2013), and healthy nutrition (i.e., fruit consumption; Kasten, van Osch, Eggers, & de Vries, 2017). These studies focused on broader operationalizations of plan enactment but did not assess differentially whether the action plan-related situation did occur when the planned behaviour was executed, which will be targeted within this study. Similar to evidence from plan enactment studies outlined above, the execution of the planned behaviour should also be a correlate of overall FV intake.

Aims and hypotheses

Extending Sniehotta's (2009) propositions, the present study examines different plan pursuit types derived from data on cue detection and execution of the planned behaviour after forming a daily FV action plan. Based on assumptions from the planning literature that underscore the importance of cue detection for successful plan pursuit (Hagger & Luszczynska, 2014), we hypothesized that frequent cue detection (i.e., at the between-person level) is related to higher overall FV intake [Hypothesis (H)1a]. Such links between cue detection and overall FV intake should also be observable at the within-person level (Inauen, Shrout, Bolger, Stadler, & Scholz, 2016). It is further assumed that, on days with higher-than-usual cue detection, individuals are more likely to report higher levels of overall FV intake on that day (H1b). Given that the frequent execution of the planned behaviour should simply lead to an additional FV serving, we assumed that frequent levels of executing the planned FV behaviour should be related to higher overall FV intake (H2a). These between-person assumptions should also be observable at the within-person level, that is, on days when individuals execute their planned behaviour more frequently than usual, higher overall FV intake on that day is more likely (H2b). In addition, it was explored whether the interaction effect between cue detection and the execution of the planned behaviour led to higher levels of overall FV intake.

Methods

Design and procedure

This study reports secondary analyses of an intensive longitudinal two-condition randomized controlled trial (RCT; Domke et al., 2021) aiming to increase FV consumption by a very brief action planning intervention. The RCT was conducted between August 2011 and November 2012 and consisted of a baseline questionnaire (Day-14), a 13-days end-of-day diary (i.e., pre-intervention diary), after which an action planning intervention (for participants assigned to the planning condition; Day 0) was conducted. Subsequently, participants responded to a 13-days post-intervention diary (Days 1–13) as well as follow-up sessions after two (Day 14) and four (Day 28) weeks (study design in Appendix S2). Participants were instructed to respond to paper–pencil-based end-of-day diaries. No prompts or reminders were sent to participants. More information regarding the recruitment approach, study design, participant flow, and procedures are provided elsewhere (Domke et al., 2021).

In primary data analyses published elsewhere (Domke et al., 2021), the effects of a brief planning intervention on adults' day-to-day overall FV intake were investigated by comparing the intervention condition (i.e., forming one FV plan) with a waiting-list control condition. Published findings indicated a differential increase of daily overall FV intake from pre- to post-intervention diary, with a discrete change between phases. In the present secondary analyses, only participants assigned to the planning condition (i.e., those who formed an FV action plan), data from the 13-days post-intervention diary, and baseline covariates were used.

Sample and recruitment

Eligible participants were at least 18 years old, had no self-reported medical conditions conflicting with health recommendations for dietary behaviour, and did not participate in weight loss or nutrition programs. Individuals were recruited in physical education classes (e.g., yoga, spinal exercises; no diet or weight loss programs) and university classes between August 2011 and November 2012. As an incentive for complete study participation, participants had the choice to either enter a lottery for health-related products or to receive course credit. At Day 0, N = 206 participants were randomly assigned to either the action planning condition (n = 106) or the waiting-list control condition (n = 100). Ninety participants from the planning condition (out of n = 106: 85%) returned the post-intervention diary and provided at least one daily report on their FV plan throughout the post-intervention diary.

Data of present analyses comprised the intervention arm subsample of n = 90 participants (80% female; mean age = 32.26 years, SD = 12.55 years, range = 19–63 years; mean body mass index (BMI) = 22.47, SD = 3.00, range = 18.00–32.77). Throughout the 13-days post-intervention diary, 1,034 daily reports on participants' FV action plans were provided (i.e., 88% out of 1,170 possible daily reports). On average, participants provided information about their plan on 11.80 days (SD = 2.24, range = 3–13).

The ethics committee of the German Psychological Society granted approval for this study.

Intervention session

Participants from the planning condition received a brief action planning intervention in which they were instructed to form an action plan for consuming one additional FV serving from the next day on. The action plan should be entered in three blank fields (*when*, *where*, and *what kind*) below an example action plan, that is, when? 'in the evening, 8 pm', where? 'in front of the television', what kind? '1 sliced apple'. Participants were asked to memorize their plan and to visualize how they would consume the planned serving of FV in the planned situation. The behaviour change techniques (BCTs; Michie et al., 2013) BCT 1.4 ('action planning') and BCT 15.2 ('mental rehearsal of successful performance') were applied (Domke et al., 2021).

Measures

Daily FV intake

Participants' daily overall FV consumption was measured using a 24-hour recall food frequency questionnaire (Pérez Rodrigo, Aranceta, Salvador, & Varela-Moreiras, 2015). A table with seven rows ('first serving', 'second serving', . . ., and 'seventh serving') and four blank columns ('when?', 'where?', 'what kind?', and 'how?') was headed with the instruction 'At which occasions did you consume fruit or vegetables today? Please be as precise as possible and use one row per serving'. One example plan was provided: when? 'at lunch-time, 12.30 pm', where? 'cafeteria', what kind? 'carrots', and how? 'raw'. One serving was explained as one handful of fruit or vegetables. Rice and potatoes did not count as FV.

Daily cue detection and execution of the planned behaviour

Cue detection and execution of the planned behaviour were operationalized as coded variables based on a comparison of the participants' FV plan with the self-reported daily FV servings for each diary day. As described above, each day, participants were asked to indicate where and when (time of day) they ate which kinds of and how much fruit and vegetables (Appendix S1).

Coding procedures. Two trained independent raters compared participants' daily self-reported FV intake with participants' daily reports on their FV plans by comparing plan components (cue detection: time, location; behaviour: type of FV) with components of all FV entries for each day. Matching entries were coded as 1, mismatching entries as 0, resulting in three dichotomous coding categories (time, location, and type of FV).[1] In case of differences in coding, discussions between both raters were conducted to reach a consensus, which was then used as the final coding. Pre-consensus inter-rater reliability (Cohen's kappa; calculated across all daily FV servings) was κ = .97 for type of FV, κ = .98 for location, and κ = .87 for time. Of the one to seven daily ratings per person, the FV serving which was most similar to the daily plan was selected (starting with the most similar cue), resulting in a total of 1,034 selected FV consumption entries (referring to 1,034 daily plan reports). The coding scheme is depicted in Table 1.

Cue detection. Subsequently, daily levels of reported cue detection were coded (i.e., same time and location in plan as in the 24-hour recall food frequency table) to derive a dummy-coded cue detection variable (1 = *cue detection*; 0 = *no cue detection*) for each day of the 13-days post-intervention diary.

[1] *Small deviations between entries were tolerated. That is, variables were coded as 1 when (time) there was a deviation of a maximum of two hours (vs. more than 2 hours), (location) a connection between places was conceivable (vs. not conceivable), and (type of FV) consumed FV included the planned one (vs. different FV consumed).*

Table 1. Coding scheme of plan pursuit after forming an action plan

Cue detection						No cue detection					
Cue detection, planned behaviour			Cue detection, different behaviour			No cue detection, planned behaviour			No cue detection, different behaviour		
What	When	Where	What	When	Where	What	When	Where	What	When	Where
1	1	1	0	1	1	1	0	1	0	0	0
						1	1	0	0	0	1
						1	0	0	0	1	0

Note. Coding of types of plan pursuit: 1 = *match*, 0 = *mismatch*.

Execution of the planned behaviour. For each diary day of the post-intervention diary, another dummy-coded variable was coded with '1 = *execution of the planned behaviour*' and '0 = *execution of a different behaviour*', based on whether the planned behaviour (i.e., the same behaviour in plan as in the 24-hour recall food frequency table) was executed or not.

Plan pursuit. The combinations for cue detection and the execution of the planned behaviour were summarized in a four-field matrix of four types of plan pursuit (Table 2).

Covariates

Covariates included participants' sex (0 = *male*, 1 = *female*), their age, BMI, the number of daily reports per person, and their past behaviour (grand mean-centred, respectively). Past behaviour was assessed at the baseline questionnaire (Day-14) by the item 'Last week, how many daily FV servings did you consume on average?' As goal intentions are proposed as important prerequisites for health behaviour change (e.g., Gollwitzer, 1999), they served as between- and within-person covariates. At the post-intervention diary, the intention was assessed using a six-point scale ranging from *completely disagree* (1) to *completely agree* (6) by the item 'I intend to consume five servings of fruit or vegetables today.'

Data analyses

Attrition analysis

Differences in baseline variables between the subsample used for present analyses (n = 90 retained participants) and the remainder (n = 16 non-retained participants) were examined using a dichotomous retainer variable and conducting χ^2- and t-tests, followed by logistic regressions.

Day-to-day associations of cue detection and execution of the planned behaviour with overall FV intake

A two-level structured dataset with time (within; level-1) nested in participants (between; level-2) was prepared. Two-level models with FV consumption as the within-person outcome were run by applying the *lmer* function in the *lme4* package (Bates, Mächler, Bolker, & Walker, 2015) in RStudio, version 1.3.1093 (RStudio Team, 2020) using

Table 2. Four-field matrix of different types of plan pursuit after forming an action plan

	Cue detection		
	Yes	No	All
Planned behaviour			
Yes	515	201	716 (69%)
No	137	181	318 (31%)
All	652 (63%)	382 (37%)	1,034

Note. Data refers to absolute numbers of daily plan reports.

restricted maximum likelihood estimation. To test for associations between types of plan pursuit and daily FV intake, three separate models were run: Model 1 tested effects of cue detection, Model 2 tested effects of the execution of the planned behaviour, and Model 3 tested the additional within-person cue detection × planned behaviour interaction.

In all models, both the between-person effect (i.e., throughout the diary) and the within-person effect (i.e., on a particular day) of study variables were included. Between-person predictors were grand mean-centred and within-person predictors were person mean-centred, respectively. To control for time effects, a linear day trend was included as a within-person predictor in all models, centred at the first day of the post-intervention diary (0–12; 0 = *Day 1*). To apply a maximal random effects structure, random effects of within-person predictors were added stepwise and retained in the final model when models converged (Barr, Levy, Scheepers, & Tily, 2013). For sensitivity analyses (Appendix S3 and S4), covariates were added to the final two-level models.

Results

Attrition analysis

Participants who provided at least one daily report on their FV plan throughout the post-intervention diary (n = 90) showed no differences on any of the baseline variables when compared with data from participants who were not retained in present analyses (n = 16).

Descriptive results

Participants consumed on average 4.02 daily FV servings (SD = 1.77; range: 0–9) throughout the 13-days post-intervention diary. Out of 1,034 daily reports, cue detection was coded in 652 daily reports (63%), whereas no cue detection occurred in 382 daily reports (37%). The execution of the planned behaviour was coded for 716 daily reports (69%) whereas different FV behaviour was performed in 318 daily reports (31%). When combined, participants reported cue detection and the consumption of the planned FV in 515 daily reports, corresponding to 50% of all daily reports, 79% out of 652 daily reports with reported cue detection, and 72% out of 716 daily reports with the execution of the planned behaviour. Note that on days with reported cue detection, participants might have additionally consumed the planned or a different FV in different situations, that is, without cue detection. Deviations from the plan (i.e., no cue detection and/or consuming another fruit or vegetable than planned) were found in the remaining 50% (i.e., 519 out of 1,034 daily observations) after forming the FV action plan.

Day-to-day associations of cue detection and execution of the planned behaviour with overall FV intake

Results of unstandardized coefficients derived from Models 1, 2, and 3 are displayed in Table 3. At the between-person level, a significant positive link between cue detection and overall FV intake (b = 1.72 servings/day; SE = 0.41, $p < .001$) was found. At the within-person level, a significantly higher daily overall FV intake (higher by 0.46 servings) was estimated for days when cue detection was higher than usual (SE = 0.11, $p < .001$).

Regarding execution of the planned behaviour, a significant between-person relationship with overall FV intake was observed (b = 1.68 servings/day; SE = 0.44, $p < .001$). At the within-person level, daily overall FV intake was significantly higher by 0.29 servings for days when participants reported higher-than-usual execution of the planned behaviour (SE = 0.10, p = .003).

In Model 3, the pattern of results found in Models 1 and 2 did not change. No significant interaction effect between cue detection and the execution of the planned behaviour was found.

In all models, the linear day trend was unrelated to daily FV intake. Sensitivity analyses revealed that the pattern of results found in all models remained the same when covariates besides intention were added as further predictors (analogous Models 1a, 2a, and 3a in Appendix S3). However, when all covariates were added to the models, significant between-person effects for cue detection diminished (analogous Models 1b, 2b, and 3b in Appendix S4). Analogous models 1c, 2c, and 3c with standardized coefficients are listed in Appendix S5.

Discussion

As secondary analyses of the intervention condition from an RCT, this study aimed at examining different types of plan pursuit based on individuals' daily cue detection and their execution of the planned behaviour for overall FV intake after forming an FV action plan. When participants pursued their FV action plan, cue detection (63%) or the execution of the planned behaviour (69%) were present for the majority of daily reports. When combined, joint cue detection and the execution of the planned behaviour were coded for half (50%) of all daily reports. In line with present hypotheses, significant relationships with overall FV intake were found for between-person and within-person cue detection as well as for between-person and within-person execution of the planned behaviour. Note that between-person effects for cue detection diminished when adding intention as a covariate to the model (sensitivity analyses). However, no significant effect for the interaction of cue detection with the execution of the planned behaviour predicting daily overall FV intake was found. This indicates that joint cue detection and execution of the planned behaviour had no impact on daily overall FV intake beyond each predictor's main effect.

Frequency of types of plan pursuit

The present study outlines different plan pursuit types for behaviour change after forming an action plan. Types of plan pursuit have been included as operationalizations of plan enactment in earlier studies. For instance, Domke, Keller, Fleig, Knoll, and Schwarzer (2019) used self-reports entered in a 7-day FV planning calendar as a plan enactment measure, which led to average plan enactment levels of 68.7%. Their operationalization

Table 3. Multilevel model estimates predicting daily fruit and vegetable consumption, with cue detection and no cue detection (Model 1), planned and different behaviour (Model 2) as predictors, as well as interaction effects of cue detection and planned behaviour (Model 3)

	Model 1			Model 2			Model 3		
Fixed effects	Est *(SE)*	*p*	95% CI	Est *(SE)*	*p*	95% CI	Est *(SE)*	*p*	95% CI
Intercept	4.12 (0.15)	**<.001**	[3.82, 4.41]	4.11 (0.15)	**<.001**	[3.81, 4.41]	4.12 (0.15)	**<.001**	[3.83, 4.41]
Between-person level									
Cue detection vs. no cue detection	1.72 (0.41)	**<.001**	[0.91, 2.53]	–	–	–	1.17 (0.48)	**.017**	[0.24, 2.11]
Planned vs. different behaviour	–	–	–	1.68 (0.44)	**<.001**	[0.82, 2.54]	1.06 (0.50)	**.037**	[0.08, 2.04]
Within-person level									
Cue detection vs. no cue detection	0.46 (0.11)	**<.001**	[0.24, 0.67]	–	–	–	0.43 (0.11)	**<.001**	[0.22, 0.65]
Planned vs. different behaviour	–	–	–	0.29 (0.10)	**.003**	[0.10, 0.48]	0.23 (0.10)	**.018**	[0.04, 0.43]
Cue detection × planned behaviour	–	–	–	–	–	–	−0.23 (0.25)	.345	[−0.72, 0.25]
Linear day trend	−0.01 (0.01)	.556	[−0.03, 0.01]	−0.01 (0.01)	.738	[−0.03, 0.02]	−0.01 (0.01)	.644	[−0.03, 0.02]

Random effects (variances)	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Intercept	1.62	[1.10, 2.31]	1.71	[1.16, 2.42]	1.59	[1.06, 2.25]
Cue detection vs. no cue detection (within-person level)	0.23	[0.01, 0.58]	–	–	0.24	[0.01, 0.58]
Linear day trend	0.01	[0.01, 0.01]	0.01	[0.01, 0.01]	0.01	[0.01, 0.01]
Residual	1.21	[0.01, 1.33]	1.25	[1.14, 1.38]	1.20	[0.01, Inf]

Note. CI = Confidence interval. Bold *p*-values indicate statistical significance at $p < .05$. Models are based on data from $n = 90$ participants and $n = 1{,}034$ observations. Intraclass correlation (ICC) for daily FV intake: 0.52 ([0.44, 0.61]), cue detection: 0.33 ([0.26, 0.42]), and planned behaviour: 0.33 ([0.25, 0.41]). The variance inflation factor (VIF) of all predictors was <2. Coefficients are unstandardized. Coefficients smaller than $|0.005|$ were rounded to 0.01 or −0.01, respectively.

and average rates of plan enactment are similar to the present study's operationalization of execution of the planned behaviour (average rate: 63%). In the context of physical activity, Fleig et al. (2017) assessed plan enactment as joint cue detection and execution of the planned behaviour by participants' ratings on a scale from 0% (not enacted as planned) to 100% (completely enacted as planned). Plan enactment scores ranged from 53.7% to 56.3% (Fleig et al., 2017), which are similar to our finding of joint cue detection and execution of the planned behaviour in 50% of daily observations.

In the present study, deviations from the plan (i.e., no cue detection and/or consuming another fruit or vegetable than planned) were found for the remaining 50% of daily observations. To tackle the issue that a certain degree of plan deviation, that is, either from cue detection or executing the planned behaviour, can occur in persons' daily life, coping plans could be formed (Spruijt-Metz & Nilsen, 2014). These would increase the likelihood of FV intake on a specific day by either specifying cues that fit better in the daily routine (e.g., 'If I am in a hurry at 8 am, I will eat an apple at 1 pm in the cafeteria.') or by replacing the initially planned FV with one that is more accessible in the specific situation (e.g., 'If I do not have an apple at home, I will eat a banana instead.').

The role of cue detection for daily FV intake

Daily overall FV intake was higher for participants with higher average cue detection (i.e., +1.72 servings; between-person level) and on days when participants reported higher-than-usual cue detection (i.e., +0.46 servings; within-person level). However, when the intention was added as a covariate (Appendix S4), between-person effects of cue detection diminished. Even for volitional processes during plan pursuit, persons' intentions to consume more FV remain a key correlate of overall FV intake (Gollwitzer & Sheeran, 2006). At the within-person level, findings support assumptions from the planning literature regarding the importance of cue detection for successful plan pursuit (Gollwitzer, 1999; Hagger & Luszczynska, 2014) and highlight the importance to differentiate between between-person and within-person relationships.

According to Gollwitzer (1999), repeated cue detection and acting upon it should facilitate the maintenance of health behaviour change by strengthening cue–response associations between the situational cue and the planned behaviour and might save resources, which can be used for self-regulatory attempts to add further FV servings on that specific day. In line with the proposal of strengthened cue–response associations, action plans are an integral part of many habit formation interventions (Kwasnicka, Dombrowski, White, & Sniehotta, 2019). In the present study, it is possible that repeated plan enactment upon cue detection may have initiated habit formation, which, when habits are formed, could have led to automaticity in enacting the planned behaviour (Gardner, 2015). Moreover, based on the literature on habit formation, the type of cue is important for repeated plan enactment (Judah, Gardner, & Aunger, 2013). Cues should be encountered often and consistently to increase the likelihood of cue detection and, subsequently, plan enactment (Gardner & Lally, 2018). The cues used in participants' action plans in the present study were location- and time-based cues (e.g., 'at 8 am' and 'in the kitchen'). As another possibility, cues could be routine-based such as 'after having breakfast'. For routine-based cues, cue detection might be easier as they allow for more flexibility and need less active monitoring (e.g., 'after having breakfast' can be easier detected than checking when the clock ticks '9 am'; Judah et al., 2013; Keller et al., 2021). Future research could encourage participants to link their planned behaviour to a routine of their daily life and subsequently examine different types of plan pursuit.

The role of executing the planned behaviour for daily FV intake

Regarding the execution of the planned behaviour, daily FV intake was higher for participants with higher average execution of the planned behaviour (i.e., +1.68 servings; between-person level) and on days when participants reported higher-than-usual execution of the planned behaviour (i.e., +0.29 servings; within-person level). Results indicated that the execution of the planned behaviour plays a crucial role in unconditional health behaviour change after forming an action plan. It can be assumed that a person who executes the planned behaviour perceives successful mastery which can lead to higher levels of self-efficacy (Bandura, 1997; Warner et al., 2018). This, in turn, could enable persons to consume further servings of FV. To gain a better understanding of these mechanisms, links with mastery experience and self-efficacy should be examined in future research (cf. Warner et al., 2018).

Synergistic effects of cue detection and execution of the planned behaviour?

Even though both cue detection and the execution of the planned behaviour, were positively linked with higher overall FV intake, there was no interaction effect. That is, joint cue detection and execution of the planned behaviour (e.g., eating an apple at 8 am in the kitchen) was not superior for daily FV intake when compared to either cue detection (e.g., eating a banana at 8 am in the kitchen) or the execution of the planned behaviour (e.g., eating an apple at 1 pm in the cafeteria). This non-finding contradicts the theoretical assumption that the driving mechanism of action planning for health behaviour change is the automatically elicited goal-directed behavioural response upon cue detection (Gollwitzer, 1999). However, the present findings indicate that substantial increases in FV intake can also take place when the planned behaviour was performed independent of the detection of the situational cue. Thus, when discussing the mechanisms of behaviour change by action planning, the importance of the execution of the planned behaviour should not be underestimated. However, mechanisms might be different for other contexts where behaviour change is more complex and difficult (e.g., smoking cessation; Scholz, Nagy, Göhner, Luszczynska, & Kliegel, 2009) or for more elaborated action plans. For instance, using more specific cues (e.g., routine- *and* time-based: 'after the morning show at 8 am') and/or FV behaviours (e.g., 'yoghurt with one sliced apple') could lead to stronger cue–response associations that unfold its effects differently. That is why, in future research, the differentiation between cue detection and the execution of the planned behaviour should be examined further.

Strengths and limitations

One of the strengths of the present study is its approach in examining different types of plan pursuit based on individuals' cue detection and their execution of the planned behaviour in the context of FV planning. Cue detection, however, is crucial also for other behavioural contexts such as handwashing behaviours, in which cue-contingent behavioural performance is important for health outcomes (e.g., infection transmission is less likely when washing hands in risky situations; Little et al., 2015). The study design comprised of intensive longitudinal assessments, which enabled the investigation of day-to-day processes of persons' daily plan pursuit and allowed to disentangle between- and within-person predictions of characteristics of persons' plan pursuit. Regarding clinical relevance, the within-person increases of overall FV intake on days when participants showed cue detection (by about half an FV portion) or executed their planned behaviour (by about a quarter FV portion) indicated that both predictors accounted for an extra 3/4 daily FV servings towards the 5 FV servings goal.

The present study also has limitations. First, a selective sample (e.g., 80% female participants) was examined which does not represent the general population. Second, the present analyses were of correlational nature, thus, no conclusions about causal relations can be drawn. Third, as the operationalization of cue detection measured only reported cue detection, participants may have detected their cue more frequently than reported (i.e., without consuming any FV). However, it can be discussed whether the conscious perception of the cue (i.e., cue detection) is needed for executing the planned behaviour or if cue exposure, even unconsciously, is sufficient. This aspect should be considered in future research. Fourth, FV intake was assessed using self-reports that are likely to be linked to methodological issues such as plan recall and social desirability bias. Objective assessments through meal photographs could complement self-reports in future studies. Finally, future studies should in general focus on technical ways of capturing intensive longitudinal data such as smartphone-based assessments and a reminder system.

Conclusion

The present study extends present conceptualizations and operationalizations of examining plan pursuit after an action planning intervention by outlining different types of plan pursuit based on individuals' cue detection and their execution of the planned behaviour for overall behaviour change (i.e., FV intake). Our findings show that cue detection, the execution of the planned behaviour as well as executing the planned behaviour in the planned situation occur frequently in the context of planning one's FV intake. Whereas within-person cue detection and between- and within-person execution of the planned behaviour were positively linked with higher FV intake, joint cue detection and execution of the planned behaviour was not superior in predicting same-day FV intake beyond each predictor's main effects.

Conflict of interest

All authors declare no conflict of interest.

Author contribution

Antonia Domke: Conceptualization; Data curation; Formal analysis; Methodology; Visualization; Writing – original draft; Writing – review & editing. **Jan Keller:** Conceptualization; Methodology; Supervision; Writing – original draft; Writing – review & editing. **Nina Knoll:** Conceptualization; Methodology; Supervision; Validation; Writing – review & editing. **Falko F. Sniehotta:** Conceptualization; Validation; Writing – review & editing. **Silke Heuse:** Investigation; Resources; Writing – review & editing. **Amelie U. Wiedemann:** Conceptualization; Investigation; Resources; Writing – review & editing.

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Data availability statement

The datasets generated during this study are not publicly available as we do not have permission from study participants. However, group-level information about the data is available from the corresponding author on reasonable request.

References

Adriaanse, M. A., Vinkers, C. D. W., De Ridder, D. T. D., Hox, J. J., & De Wit, J. B. F. (2011). Do implementation intentions help to eat a healthy diet? A systematic review and meta-analysis of the empirical evidence. *Appetite*, *56*(1), 183–193. https://doi.org/10.1016/j.appet.2010.10.012

Aune, D., Giovannucci, E., Boffetta, P., Fadnes, L. T., Keum, N., Norat, T., . . . Tonstad, S. (2017). Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality: A systematic review and dose-response meta-analysis of prospective studies. *International Journal of Epidemiology*, *46*(3), 1029–1056. https://doi.org/10.1093/ije/dyw319

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255–278. https://doi.org/10.1016/j.jml.2012.11.001

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Bélanger-Gravel, A., Godin, G., & Amireault, S. (2013). A meta-analytic review of the effect of implementation intentions on physical activity. *Health Psychology Review*, *7*(1), 23–54. https://doi.org/10.1080/17437199.2011.560095

de Vries, H., Eggers, S. M., & Bolman, C. (2013). The role of action planning and plan enactment for smoking cessation. *BMC Public Health*, *13*(1), 393. https://doi.org/10.1186/1471-2458-13-393

Domke, A., Keller, J., Fleig, L., Knoll, N., & Schwarzer, R. (2019). What makes a good action plan? Characteristics and enactment of fruit and vegetable plans. *Appetite*, *142*, 104351. https://doi.org/10.1016/j.appet.2019.104351

Domke, A., Keller, J., Heuse, S., Wiedemann, A. U., Lorbeer, N., & Knoll, N. (2021). Immediate effects of a very brief planning intervention on fruit and vegetable consumption: A randomized controlled trial. *Applied Psychology: Health and Well-Being*, *13*, 377–393. https://doi.org/10.1111/aphw.12254

Fleig, L., Gardner, B., Keller, J., Lippke, S., Pomp, S., & Wiedemann, A. U. (2017). What contributes to action plan enactment? Examining characteristics of physical activity plans. *British Journal of Health Psychology*, *22*, 940–957. https://doi.org/10.1111/bjhp.12263

Gardner, B. (2015). A review and analysis of the use of 'habit' in understanding, predicting and influencing health-related behaviour. *Health Psychology Review*, *9*, 277–295. https://doi.org/10.1080/17437199.2013.876238

Gardner, B., & Lally, P. (2018). Modelling habit formation and its determinants. In B. Verplanken (Ed.), *The psychology of habit: Theory, mechanisms, change, and contexts* (pp. 207–229). Cham, Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-97529-0_12

Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist*, *54*(7), 493–503. https://doi.org/10.1037/0003-066X.54.7.493

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in Experimental Social Psychology*, *38*, 69–119. https://doi.org/10.1016/S0065-2601(06)38002-1

Hagger, M. S., & Luszczynska, A. (2014). Implementation intention and action planning interventions in health contexts: State of the research and proposals for the way forward. *Applied Psychology: Health and Well-Being*, *6*(1), 1–47. https://doi.org/10.1111/aphw.12017

Hall, J. N., Moore, S., Harper, S. B., & Lynch, J. W. (2009). Global variability in fruit and vegetable consumption. *American Journal of Preventive Medicine*, *36*(5), 402–409.e5. https://doi.org/10.1016/j.amepre.2009.01.029

Inauen, J., Shrout, P. E., Bolger, N., Stadler, G., & Scholz, U. (2016). Mind the gap? An intensive longitudinal study of between-person and within-person intention-behavior relations. *Annals of Behavioral Medicine*, *50*(4), 516–522. https://doi.org/10.1007/s12160-016-9776-x

Judah, G., Gardner, B., & Aunger, R. (2013). Forming a flossing habit: An exploratory study of the psychological determinants of habit formation. *British Journal of Health Psychology*, *18*(2), 338–353. https://doi.org/10.1111/j.2044-8287.2012.02086.x

Kasten, S., van Osch, L., Eggers, S. M., & de Vries, H. (2017). From action planning and plan enactment to fruit consumption: Moderated mediation effects. *BMC Public Health*, *17*(1), 832. https://doi.org/10.1186/s12889-017-4838-y

Keller, J., Kwasnicka, D., Klaiber, P., Sichert, L., Lally, P., & Fleig, L. (2021). Habit formation following routine-based versus time-based cue planning: A randomized controlled trial. *British Journal of Health Psychology*, *26*(3), 807–824. https://doi.org/10.1111/bjhp.12504

Kwasnicka, D., Dombrowski, S. U., White, M., & Sniehotta, F. F. (2019). 'It's not a diet, it's a lifestyle': A longitudinal, data-prompted interview study of weight loss maintenance. *Psychology & Health*, *34*(8), 963–982. https://doi.org/10.1080/08870446.2019.1579913

Little, P., Stuart, B., Hobbs, F. D. R., Moore, M., Barnett, J., Popoola, D., . . . Yardley, L. (2015). An internet-delivered handwashing intervention to modify influenza-like illness and respiratory infection transmission (PRIMIT): A primary care randomised trial. *The Lancet*, *386*(10004), 1631–1639. https://doi.org/10.1016/S0140-6736(15)60127-1

Livingstone, K. M., Burton, M., Brown, A. K., & McNaughton, S. A. (2020). Exploring barriers to meeting recommendations for fruit and vegetable intake among adults in regional areas: A mixed-methods analysis of variations across socio-demographics. *Appetite*, *153*, 104750. https://doi.org/10.1016/j.appet.2020.104750

Mensink, G., Schienkiewitz, A., & Lange, C. (2017a). *Gemüsekonsum bei Erwachsenen in Deutschland [Vegetable consumption of adults in Germany]*. https://doi.org/10.25646/2574

Mensink, G., Schienkiewitz, A., & Lange, C. (2017b). *Obstkonsum bei Erwachsenen in Deutschland [Fruit consumption of adults in Germany]*. https://doi.org/10.25646/2577

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., . . . Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine*, *46*(1), 81–95. https://doi.org/10.1007/s12160-013-9486-6

Orbell, S., Hodgkins, S., & Sheeran, P. (1997). Implementation intentions and the theory of planned behavior. *Personality and Social Psychology Bulletin*, *23*, 945–954. https://doi.org/10.1177/0146167297239004

Pérez Rodrigo, C., Aranceta, J., Salvador, G., & Varela-Moreiras, G. (2015). Food frequency questionnaries. *Nutrición Hospitalaria*, *31*(Suppl. 3), 49–56. https://doi.org/10.3305/nh.2015.31.sup3.8751

RStudio Team (2020). *RStudio: integrated development for R. RStudio, PBC*. RStudio Team. Retrieved from: http://www.rstudio.com/

Scholz, U., Nagy, G., Göhner, W., Luszczynska, A., & Kliegel, M. (2009). Changes in self-regulatory cognitions as predictors of changes in smoking and nutrition behaviour. *Psychology & Health*, *24*, 545–561. https://doi.org/10.1080/08870440801902519

Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology*, *57*(1), 1–29. https://doi.org/10.1111/j.1464-0597.2007.00325.x

Sniehotta, F. F. (2009). Towards a theory of intentional behaviour change: Plans, planning, and self-regulation. *British Journal of Health Psychology*, *14*, 261–273. https://doi.org/10.1348/135910708X389042

Spruijt-Metz, D., & Nilsen, W. (2014). Dynamic models of behavior for just-in-time adaptive interventions. *IEEE Pervasive Computing*, *13*, 13–17. https://doi.org/10.1109/MPRV.2014.46

Warner, L. M., Stadler, G., Lüscher, J., Knoll, N., Ochsner, S., Hornung, R., & Scholz, U. (2018). Day-to-day mastery and self-efficacy changes during a smoking quit attempt: Two studies. *British Journal of Health Psychology*, *23*, 371–386. https://doi.org/10.1111/bjhp.12293

Wiedemann, A. U., Lippke, S., & Schwarzer, R. (2012). Multiple plans and memory performance: Results of a randomized controlled trial targeting fruit and vegetable intake. *Journal of Behavioral Medicine*, *35*, 387–392. https://doi.org/10.1007/s10865-011-9364-2

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Supporting Information

The following supporting information may be found in the online edition of the article:

Appendix S1. Sample fruit and vegetable servings of two participants with five and four total servings for the selected sample day.
Appendix S2. Study design.
Appendix S3. Sensitivity analyses: estimates of multilevel models predicting fruit and vegetable consumption, with age, sex, body-mass-index, number of daily reports, and past behaviour as covariates.
Appendix S4. Sensitivity analyses: estimates of multilevel models predicting fruit and vegetable consumption, with age, sex, body-mass-index, number of daily reports, past behaviour, and intention as covariates.
Appendix S5. Multilevel model estimates predicting daily fruit and vegetable consumption, with cue detection and no cue detection (Model 1c), planned and different behaviour (Model 2c) as predictors, as well as interaction effects of cue detection and planned behaviour (Model 3c), with standardized coefficients.